FERROELASTIC CERAMIC-REINFORCED METAL MATRIX COMPOSITES

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 10/851,022 filed May 23, 2003, which is herein incorporated by reference.

GOVERNMENT CONTRACT

[0002] The United States Government has certain rights to this invention pursuant to Contract No. DAA 19-01-1-0714 awarded by the U.S. Army Research Office.

FIELD OF THE INVENTION

[0003] The present invention relates to ferroelastic ceramic-reinforced metal matrix composite materials which are useful for structural applications, and which are capable of passively damping vibrations.

BACKGROUND INFORMATION

[0004] Structural materials and components that would benefit from vibration damping include automobile components, aircraft components, marine components, building components, hand tools, sports equipment, propulsion units, space structures, platforms and the like.

[0005] Many materials used in various structural applications possess relatively poor vibration damping characteristics. Vibration damping in structural high-load components is currently achieved through the use of external components such as elastomeric mounting materials or actively controlled vibration dampers. Vibration reduction is thus achieved through the use of damping materials and components that are often added extrinsically to the existing structure.

[0006] The present invention has been developed in view of the foregoing.

SUMMARY OF THE INVENTION

[0007] The present invention provides a metal matrix composite material reinforced with discontinuous ferroelastic ceramic particulates, which are dispersed in the metallic matrix. The inclusion of ferroelastic ceramic particulates allows the composite to exhibit exceptional passive damping capabilities while maintaining a high degree of structural strength. The composites provide passive vibration damping through the conversion of strain to twinning of the ferroelastic domains in response to an applied stress. The present composite materials can be used in high load applications without the need for additional vibration damping materials. Additionally, the matrix may be further strengthened through dispersion strengthening mechanisms that involve the presence of effective obstacles to dislocation motion. Improved combinations of structural strength and vibration damping are achieved with the present materials.

[0008] An aspect of the present invention is to provide a method of damping vibrations in a structural component by forming at least part of the structural component from a composite material comprising a metal matrix and ferroelastic ceramic particulates dispersed therein.

[0009] Another aspect of the present invention is to provide a vibration damping structural component comprising a composite material including a metal matrix and ferroelastic ceramic particulates dispersed in the metal matrix.

[0010] A further aspect of the present invention is to provide a method of making a vibration damping composite material by dispersing ferroelastic ceramic particulates in a metal matrix to thereby produce the vibration damping composite material.

[0011] These and other aspects of the present invention will be more apparent from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. **1** is a partially schematic illustration of a composite material comprising a metal matrix with ferroelastic ceramic particulates dispersed therein in accordance with an embodiment of the present invention.

[0013] FIG. **2***a*-**2***c*. illustrate spherical, spheroidal and disc shapes of ferroelastic ceramic particulates, respectively, in accordance with embodiments of the present invention.

[0014] FIG. **3** is a graph illustrating vibration damping characteristics for a composite material comprising a Cu—Sn metal matrix with 50 volume percent $BaTiO_3$ ferroelastic ceramic particulates dispersed therein in accordance with an embodiment of the present invention, showing an increase in vibration damping ability below the Curie temperature of the $BaTiO_3$ reinforcements.

[0015] FIG. **4** is an graph illustrating normalized peak intensity at a first and second detector for $BaTiO_3$ (200) and (002) planes from in situ neutron diffraction during cyclic loading of a (Cu—Sn)$BaTiO_3$ composite material of the present invention at 25° C.

[0016] FIG. **5** is a micrograph of a Ni—$BaTiO_3$ composite material produced in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

[0017] FIG. **1** schematically illustrates a composite material **10** capable of damping vibrations in accordance with an embodiment of the present invention. The composite **10** comprises a metal matrix **12** and ferroelastic ceramic particulates **14** dispersed in the metal matrix **12**. When vibrations occur in the composite **10**, the metal matrix **12** and ferroelastic particulates **14** are strained. This induces twinning, which is also referred to as domain motion or domain rotation, within the ferroelastic particulates **14**. The composite **10** is thus able to transfer incoming vibrations into energy used to form twins in some of the ferroelastic domains. The ferroelastic ceramic particulates **14** may also strengthen the metal matrix **12** through common dispersion strengthening mechanisms such as dislocation motion hindering.

[0018] As used herein, the terms "structural material" and "structural component" mean materials and components that are subjected to mechanical loading during use. Such mechanical loading may include vibration as well as compression, tension, bending, multiaxial loading, and the like.

[0019] As used herein, the term "metal matrix" means an interconnected or continuous network comprising at least